DOCUMENT RESUME

ED 113 207 SE 019 818

TITLE	Nuclear Weapons Effects (Self-Teaching Materials).
INSTITUTION	Defense Civil Preparedness Agency (DOD), Battle Creek, Mich.
REPORT NO	SM-2.1.2
PUB DATE	Jul 75
NOTE	122p.
EDRS PRICE	MF-$0.76 HC-$5.70 Plus Postage
DESCRIPTORS	*Autoinstructional Aids; *Civil Defense; Environment; Individualized Instruction; *Instructional Materials; Military Science; *Nuclear Warfare; Radiation; *Radiation Effects; Science Education; Self Help Programs

ABSTRACT

Developed by the Civil Defense Preparedness Agency, this autoinstructional text deals with nuclear weapons effects. The destructive effects of an atomic blast are first introduced, and then long-term radioactive consequences are stressed. (CP)

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Supersedes SM-2.1.2 dated December 1972 which may be used

SM-2.1.2.
July 1975

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ED113207

NUCLEAR WEAPONS EFFECTS

(Self-Teaching Materials)

SE 019 818

STAFF COLLEGE BATTLE CREEK, MICHIGAN • DEFENSE CIVIL PREPAREDNESS AGENCY

SECTION I

INTRODUCTION

This text is organized to teach you the facts you need to know about NUCLEAR WEAPONS EFFECTS.

To proceed through this text you need only continue from this page. On each page, read the information and/or directions given you carefully, answer any questions asked, and follow the instructions given you on each page.

There are just a few penalties for errors that will impede your progress. You will find that each succeeding page assumes that you either know already, or have learned by use of the text, the information on the previous pages, so, check yourself before going on from page to page. Your reward is to be found in your consistent and steady progress through the text and your increased knowledge of nuclear weapons.

Please follow all directions carefully. Now turn to page 3 and begin.

GOOD LUCK!

3

Now, how did you get to this page? We told you to read carefully and follow instructions. Nowhere in this publication are you directed to turn to this page.

Follow instructions carefully, and turn to the page to which you are directed.

Turn to page 3.

Both the military forces and the civilian population of the United States may be endangered by the effects of modern weapons. Our country must prepare to protect itself against any weapon which might be used in an attack. There are four possibilities:

1. Conventional.
2. Chemical.
3. Biological.
4. Nuclear.

Weapons which depend on TNT or similar non-nuclear explosives for their effectiveness are classified as "conventional." These include many of the weapon types used during World War II and the Korean War -- shells, torpedoes, rockets, mines, and bombs. Adequate preparation for defense against nuclear attack is more than adequate to prepare for coping with conventional weapons; the converse is not true.

Preparation for defense against a missile attack, using nuclear warheads, would provide sufficient preparation to cope with a conventional attack.

The above statement is:

True - Turn to page 4.

False - Turn to page 5.

We agree with you that preparation for defense against a nuclear attack would provide sufficient protection for defense against a conventional attack. Another method of attack would be with chemical and biological agents.

Chemical agents are tear gas, mustard gas, nerve gas, and similar chemical compositions. Biological agents are disease producing microorganisms (sometimes called germs) or producer of poisons (toxins). Chemical and biological agents have certain characteristics in common. They are both designed to cause injury, illness, or death to living things. Both can be spread by airplane spray, guided missiles, aerial bombs, etc.

Many studies have been made concerning the relative threat posed to the survival of this Nation by nuclear weapons and chemical and biological agents. These studies quite conclusively indicate that, at the present time, nuclear weapons pose the most serious threat. Knowledge about practical application of biological agents is insufficient to indicate when, if ever, this threat might become a reality. The threat of chemical and biological agents is being kept under constant review.

Select one of the following statements:

1. I believe that chemical agents, such as mustard gas, are dangerous and we should protect against them. We should supply protective (gas) masks instead of shelters. Turn to page 6.

2. I know how easily contagious diseases are spread and I believe that more people would be killed by biological agents than could be killed by nuclear attack. Turn to page 7.

3. I believe that more people would be killed by nuclear weapons than by chemical or biological weapons. Turn to page 8.

You selected false. You believe that adequate preparation for defense against a nuclear attack would not provide protection against conventional warfare. The destruction caused by a large yield nuclear explosion is tremendously greater than the destruction caused by a conventional weapon. A conventional weapon produces blast and heat, but to a much lesser degree than a nuclear weapon, and a conventional weapon does not produce radioactive material. Millions of persons could be killed by the radiological effects of nuclear weapons, that might survive a conventional attack. It would require a tremendous number of conventional weapons to produce the damage of even a small size nuclear weapon.

During World War II, Hamburg, Germany, was under almost constant attack for eight days, and Hiroshima was hit with ONE small yield nuclear weapon. The destruction was approximately equal.

Turn to page 4.

You believe that chemical agents are dangerous and that we should supply protective masks instead of shelters.

We agree that chemical agents are dangerous, and a horrible means of warfare. We also agree that some deaths could be caused by chemical agents. However, the space required in missiles to produce casualties over a large area with chemical agents, could easily carry many megatons of nuclear weapons, which would produce considerable destruction and far more deaths. We do not agree that we should replace shelters with protective masks. Radioactive fallout alone, without the protection of shelter, could kill 40 million or more people. The shelter program is being developed to protect these 40 million people.

Many studies have been made concerning the relative threat possibilities of all types of attack. These studies have been projected to include the estimated capabilities of any enemy in the late 1970's. All of these studies conclusively indicate that the greatest threat to the survival of the Nation is a nuclear attack. Therefore, the greatest emphasis of the Civil Preparedness Program is geared toward developing a system of protection against the greatest threat, while constantly watching the development of lethal weapons which could change this strategy.

Turn to page 8.

You believe that more people could be killed by biological agents than by nuclear attack. We do not agree with you.

Biological agents are a threat and could cause the loss of lives. The difficulty in the use of biological agents is:

1. Dissemination is generally unreliable. Much of the agent material is killed by storage, dissemination, and weathering.

2. It is difficult to spread biological agents in the exact area where population is concentrated. Biological agents will not destroy facilities, or rapidly degrade an enemy's ability to retaliate.

3. Most biological agents require an incubation period of several days to weeks in order to produce casualties.

4. Vaccination and other protective measures can reduce possible spread of the disease.

Turn to page 8.

We agree. Now, let's take a closer look at this nuclear weapon.

The nuclear bomb was designed as a blast weapon. Therefore, although immensely more powerful, it resembles bombs of the conventional type, insofar as its destructive effect is due mainly to the blast or shock that follows the detonation. However, nuclear detonations do differ from conventional detonations in four important respects:

1. A fairly large amount of the energy from a nuclear detonation is emitted as THERMAL RADIATION, generally referred to as LIGHT AND HEAT.

2. The explosion is accompanied by highly-penetrating, harmful but INVISIBLE NUCLEAR RADIATIONS.

3. The nuclear reaction PRODUCTS, which remain after the detonation, are RADIOACTIVE, emitting nuclear radiations capable of producing harmful consequences in living organisms.

4. Nuclear explosions can be many thousands (or millions) of times more powerful than the largest conventional detonations.

Select the correct statements:

a. Nuclear detonations produce heat, blast and nuclear radiation.

b. Nuclear explosions can be millions of times more powerful than conventional weapons.

c. Conventional weapons are accompanied by highly-penetrating, harmful but invisible nuclear radiations.

If you believe that the correct statements are:

a, b, and c - Turn to page 9.
a and c - Turn to page 10.
a and b - Turn to page 11.
b and c - Turn to page 12.

You selected a, b and c as true. We agree that a and b are true, but we do not agree with your selection of c.

The statement in c was: Conventional weapons are accompanied by highly-penetrating, harmful but invisible nuclear radiations.

Conventional weapons do NOT produce nuclear radiation. Conventional weapons produce blast and heat but they do not produce radioactive materials.

Return to page 8 and select another answer.

You selected a and c as true. We agree that a is true, but we disagree with you that c is true.

The statement in c was: Conventional weapons are accompanied by highly-penetrating, harmful but invisible nuclear radiations.

Conventional weapons do NOT produce nuclear radiation. Conventional weapons produce heat and blast but they do not produce radioactive materials.

Return to page 8 and select another answer.

We agree again. Proceed.

The power of a nuclear weapon is expressed in terms of the energy release (or yield) when it explodes compared with the energy liberated by the explosion of TNT. Thus, a 1 kiloton nuclear weapon is one which produces the same amount of energy in an explosion as does 1 kiloton or (1,000 tons) of TNT. Similarly, a 1 megaton weapon would have the energy equivalent of 1 million tons (or 1,000 kilotons) of TNT. The earliest nuclear weapons, such as those dropped over Japan in 1945, and those used in the tests at Bikini in 1946, released roughly the same amount of energy as 20,000 tons (or 20 kilotons) of TNT. Since that time, much more powerful weapons, with energy yields in the megaton range, have been developed.

Select the correct statements:

1. A kiloton equals a thousand tons of TNT.
2. A megaton equals a million tons of TNT.
3. A megaton equals a thousand kilotons.

If you believe that the correct statements are:

1, 2, and 3 - Turn to page 13.

1, and 3 - Turn to page 14.

1, and 2 - Turn to page 15.

2, and 3 - Turn to page 16.

You selected b and c as the correct answer. We agree that b is a correct answer, but we do not agree with your selection of c.

c. Conventional weapons are accompanied by highly-penetrating, harmful but invisible nuclear radiations.

Conventional weapons do NOT produce nuclear radiation. Conventional weapons produce heat and blast but they do not produce any radioactive materials.

Return to page 8 and select another answer.

You are doing well, continue.

FISSION

Nuclear FISSION is the splitting of heavy atomic nuclei. The nucleus of an atom of a heavy element such as uranium may be split into two or more parts. This splitting of atomic nuclei is accompanied by the release of enormous energy.

Self-sustaining fission reactions occur only with the heavy elements, uranium, plutonium, or thorium. When a fissionable nucleus is split by a neutron it releases energy and one or more neutrons. These neutrons may split other fissionable nuclei, releasing more energy and more neutrons. In a nuclear explosion this reaction becomes self-sustaining.

The complete fission of 1 pound of uranium or of plutonium releases as much energy as the explosion of 8,000 tons of TNT.

Select the correct statement:

If we assume that a nuclear weapon is 50% efficient, that is half of the nuclei are split by neutrons, it would require approximately _____ lb(s). of uranium to produce a 20 kiloton explosion.

1. 1 lb. - Turn to page 17.
2. 3 lbs. - Turn to page 18.
3. 5 lbs. - Turn to page 19.

You selected 1 and 3 as true. They are both true answers, but 2 is also true, therefore, your best choice should have been 1, 2, and 3. A megaton, by definition, is the equivalent of a million tons of TNT.

Remember the following:

Megaton - equals a million tons of TNT.

Kiloton - equals a thousand tons of TNT.

Megaton - equals a thousand kilotons.

Turn to page 13.

You selected 1 and 2 as true. They are both true answers, but 3 is also true, therefore, your best choice should have been 1, 2, and 3.

If a kiloton equals a thousand tons of TNT, and
a megaton equals a million tons of TNT, then
a megaton equals a thousand kilotons. One million divided by 1,000.

Turn to page 13.

You selected 2 and 3 as correct. They are both true answers, but 1 is also true, therefore, your best choice should have been 1, 2, and 3.

Remember the following:

Kiloton - equals a thousand tons of TNT.

Megaton - equals a MILLION tons of TNT.

Megaton - equals a thousand kilotons. One million divided by a thousand.

Turn to page 13.

You selected 1 lb. as your answer. You are wrong.

We said that the complete fission of 1 pound of uranium or of plutonium releases as much energy as the explosion of 8,000 tons of TNT. Rarely do we have perfection in any transfer of energy, therefore we made the assumption in the last problem that only 50% efficiency was obtained. This would indicate that for each pound of uranium or plutonium, the energy released would be approximately the equivalent of 4,000 tons of TNT (one-half of 8,000).

Twenty (20) kilotons are equivalent to 20,000 tons of TNT.

Divide 4,000 (energy per pound) into 20,000 (energy equivalent of a kiloton) and the answer is 5 lbs.

Try this problem:

If we assume that a nuclear weapon is 25% efficient, that is, one-fourth of the nuclei are split by neutrons, it would require approximately _____ lb(s). of uranium to produce a 10 kiloton explosion.

Your answer should be 5 lbs.

Turn to page 19.

587-651 O - 75 - 2

You selected 3 lbs. as your answer. You are wrong.

We said that the complete fission of 1 pound of uranium or plutonium releases as much energy as the explosion of 8,000 tons of TNT. Rarely do we have perfection in any transfer of energy, therefore, we made the assumption in the last problem that only 50% efficiency was obtained. This would indicate that for each pound of uranium or plutonium, the energy released would be approximately the equivalent of 4,000 tons of TNT (one-half of 8,000).

Twenty (20) kilotons are equivalent to 20,000 tons of TNT.

Divide 20,000 (power equivalent of a kiloton) by 4,000 (energy per pound) and the answer is 5 lbs.

Try this problem:

> If we assume that a nuclear weapon is 25% efficient, that is, one-fourth of the nuclei are split by neutrons, it would require approximately _____ lb(s). of uranium to produce a 10 kiloton explosion.

Your answer should be 5 lbs.

Turn to page 19.

You selected 5 lbs. You are correct, proceed.

FUSION

Nuclear FUSION is the joining together of light atomic nuclei to form a heavier nucleus. Such fusion can only be accomplished under conditions of very high temperature (millions of degrees). If two nuclei of light atoms fuse, the fusion is accompanied by the release of a great deal of energy. The energy of the sun, for example, results from the fusion of certain light atoms to form heavier ones. Much of the power from a thermonuclear weapon (hydrogen or H-bomb) results from the fusion process. Most atoms formed by the FUSION process are NOT radioactive; atoms formed by FISSION process are highly radioactive.

Nuclear fusion reactions can be brought about by means of very high temperatures, and they are thus referred to as "thermonuclear processes." The actual quantity of energy liberated, for a given mass of material, depends on the particular material involved in the nuclear fusion reaction. As an example, the fusion of all the nuclei present in 1 pound of the hydrogen isotope, deuterium, would release roughly the same amount of energy as the explosion of 26,000 tons of TNT.

If we desired a warhead for a missile that pound for pound would produce the greatest area of fire, blast, and a high degree of radioactive residue, we would select one that produces its energy through the:

1. Fusion process - Turn to page 20.
2. Fission process - Turn to page 21.
3. A combination fusion and fission process - Turn to page 22.

You selected the fusion process. You are wrong.

The fusion process does produce the greatest heat and blast, pound for pound, but the fusion process does not produce radioactive residues, therefore, your selection was not the best answer.

The fusion process produces the greatest blast and fire effects, but does NOT produce large amounts of nuclear radiation.

The fission process produces less blast and fire effects, but does produce large amounts of radioactive materials.

The combination fission, fusion process would combine the increased blast and fire effects of the fusion process and add the radiation effects of fission.

To obtain the most effective blast and fire effects, with radioactive residue, it would require a combination of fission for radioactive residue, and fusion for increased blast and heat effects.

Proceed to page 22.

You selected the fission process. You are wrong.

The fission process does produce blast and fire effects, and it does produce radioactive residue. We asked for the selection that would produce the greatest area of blast and fire and produce radioactive residue.

Fusion produces the greatest area of blast and fire, but does not produce radioactive residue.

To obtain the greatest blast and fire effects, and produce radioactive residue, we would select the combination process. This would provide much of the additional energy produced by the fusion process and would provide radioactive residue by the use of the fission process.

Proceed to page 22.

CORRECT!

We're doing well. Move on.

DISTRIBUTION OF ENERGY

Although the detonation of a chemical explosive, such as TNT, and the detonation of a nuclear weapon both produce heat or thermal radiation, the proportion as well as the quantity is much higher in the case of the nuclear weapon. The basic reason for this difference is that, weight for weight, the energy produced in a nuclear explosion can be millions of times as great as that in a chemical explosion. Consequently, the temperatures reached in the nuclear explosion are much higher than in a chemical explosion.

For a nuclear detonation in the atmosphere below 100,000 feet, about 85% of the total energy appears first as intense heat. Almost immediately a considerable part of this heat is converted to blast or shock; the remaining thermal energy moves radially outward at the speed of light as thermal radiation and visible light. The remaining 15% of the energy of the nuclear explosion is classified in two ways: 5% constitutes the nuclear radiation produced within the first minute after explosion (INITIAL RADIATION) and 10% of the energy is in the form of residual radiation (from fallout) emitted over a long period of time.

In a nuclear detonation, about 15% of the total energy is expended in the form of nuclear radiation.

If you believe that the above statement is:

True - Turn to page 23.

False - Turn to page 24.

We're doing fine. Proceed to types of bursts.

TYPES OF BURSTS

An enemy might use nuclear weapons in various ways, depending on the results he seeks. He must consider the system for delivering the weapons, such as aircraft for dropping nuclear bombs or missiles armed with nuclear warheads. He must also consider the effects of various weapon yields and types of burst. The energy yield of an explosion and its point of detonation largely determine how much of an area would be destroyed, what types of partial or total damage would be inflicted, and how widespread the radioactive fallout and other secondary effects would be. A nuclear weapon may be detonated high in the air, or at the surface of land or water, or even after the weapon has penetrated below the surface.

The three types of burst are:

1. Air burst.
2. Surface burst.
3. Subsurface burst.

Turn to page 25.

You selected false. We are not together. Let's see if we can clear up the misunderstanding.

A fission weapon detonated in the atmosphere below 100,000 feet will initially expend about 85% of its energy in intense heat. A portion of this heat is quickly converted into blast or shock. The remaining 15% is converted to INITIAL NUCLEAR RADIATION AND RESIDUAL NUCLEAR RADIATION (from fallout). We then stated that 5% constitutes INITIAL RADIATION and 10% constitutes RESIDUAL RADIATION. The total amount of energy converted to nuclear radiation is approximately 15%.

Return to page 23.

An AIR BURST is defined as one in which the bomb is exploded in the air so high above land or water that the fireball (at maximum diameter) does not touch the surface of the earth. The greatest area of blast and heat is produced by a low air burst. The amount of local fallout from this type of burst is negligible and is not considered a civil defense problem. The population would not have to remain in shelters for protection from fallout.

Select the correct statements:

An air burst would likely be used to meet these conditions:

1. Produce the greatest area of fire.
2. Produce the greatest fallout hazard.
3. Produce the greatest area of blast.

If you believe that:

1 and 2 are true - Turn to page 26.

1 and 3 are true - Turn to page 27.

1, 2, and 3 are true - Turn to page 28.

2 and 3 are true - Turn to page 29.

You selected 1 and 2. We agree with your choice of 1, but we do not agree with your selection of 2.

A low air burst produces the greatest area of blast and heat, but does not present a problem of fallout. The amount of fallout is not a problem that requires the population to take shelter against its effects.

A low air burst would be used to produce the maximum <u>area</u> of destruction from blast and heat. It DOES NOT produce a radioactive fallout problem for Civil Defense.

Return to page 25 and try again.

We agree with your selections. We understand the effects of an air burst, now let's look at a SUBSURFACE BURST.

A SUBSURFACE BURST is one in which the center of a nuclear explosion occurs under the ground or underwater. Underground or underwater shock is produced, and, according to the depth at which the explosion occurs, some of the shock may escape to produce air blast. Much of the heat wave and immediate nuclear radiation is absorbed within a short distance by the ground or water. However, large amounts of earth or water near the explosion will be contaminated with radioactive materials. By comparison with a surface or low air burst, a subsurface burst in which the fireball is visible, produces the greatest area of ground shock, severe fallout in the immediate area of the burst, and the least serious thermal radiation and blast effects.

A subsurface burst would produce the greatest ground shock, and therefore, would cause greater damage to underground shelters and missile silos than an air burst. The area near the point of detonation (ground zero) would be highly radioactive. A subsurface burst would NOT produce as large an area of fire and blast damage as an air burst.

Read the following statement and select the best answer:

If we desired to destroy parked military planes and vehicles on a very large air base, we would probably select:

1. A subsurface burst - Turn to page 30.
2. An air burst - Turn to page 31.

You selected 1, 2, and 3. We agree with your choice of 1 and 3, but we do not agree with your choice of 2.

A low air burst produces the greatest area of blast and fire, but does not present a serious problem of fallout. The amount of fallout is not a problem that requires the population to take shelter against its effects.

An air burst would be used to produce a large <u>area</u> of destruction from blast and heat. An air burst DOES NOT produce a radioactive fallout problem for Civil Defense.

Return to page 25 and try again.

You selected 2 and 3. We agree with your choice of 3, but we do not agree with your selection of 2.

A low air burst produces the greatest area of blast and fire, but does not present a serious problem of fallout. The amount of fallout is not a problem that requires the population to take shelter against its effects.

An air burst would be used to produce a large area of destruction from blast and heat. It does NOT produce a radioactive fallout problem for Civil Defense.

Return to page 25 and try again.

You selected a subsurface burst to destroy parked planes and military vehicles on a large air base. We disagree with you.

Our objective in the previous statement was to destroy the planes and vehicles on the base. A subsurface burst which produces a visible fireball would contaminate the airport with radioactive particles, and therefore, probably put the airbase out of operation for a period of time due to high radiation levels, but the planes and vehicles might not have been destroyed.

An air burst would have created blast damage over a much larger area and destroyed many more, if not all, vehicles and planes.

If our objective had been to create a radiation hazard for a considerable period of time, to prevent use of the runways, then we might have selected the subsurface burst.

Remember, an air burst can create the greatest area of blast and fire damage. An air burst does not present a radioactive fallout problem.

A subsurface burst creates underground shock, and if the fireball erupts through the surface of the earth, it can produce close-in fallout. The area of detonation in such a subsurface burst is highly radioactive.

Proceed to page 31.

Now that we know the effects of an air burst and a subsurface burst, let's take a look at the surface burst.

In a SURFACE BURST the ball of fire touches the ground. Because of its intense heat, rock, soil, and other materials (some vaporized) will rise up into the cloud. An important difference between a surface burst and an air burst is that in the surface burst, the atomic cloud contains particles on and in which the radioactive materials are deposited and brought back down to earth. In a surface burst a serious fallout problem is created over a large area. The area of destruction is completely destroyed, but compared to an air burst less total area of blast and fire is created.

Complete the following statement:

If an enemy desired to destroy a group of factories, and pin down the population over an extensive area by making them remain in shelter, a (an) _____ of sufficient size would be used.

1. Air burst - Turn to page 32.
2. Subsurface burst - Turn to page 33.
3. Surface burst - Turn to page 34.

You selected an air burst. This would not result in fallout. An air burst does produce the greatest area of fire and blast.

Return to page 31 and try again.

You selected a subsurface burst. A subsurface burst would produce the greatest amount of ground shock, and would destroy those buildings close to the point of detonation. If the fireball erupted through the earth, there would be very serious fallout close to the point of detonation, but not over an extensive area. The surface burst will result in early fallout over the greatest area.

Return to page 31 and try again.

587-851 O - 75 - 3

You selected a surface burst. We agree. Now, let's review.

Complete the following statements:

1. Many studies have been made concerning the relative threat posed to the survival of this Nation by nuclear weapons and chemical and biological agents. At the present time _____ pose the most serious threat.

2. Conventional weapons and nuclear weapons both produce blast and heat, but only _____ weapons produce radioactive products.

3. A kiloton equals _____ tons of TNT.

4. A megaton equals _____ tons of TNT.

5. Two types of nuclear raction are Fission and Fusion. The _____ process produces greater release of energy per pound than the _____ process.

6. The three types of burst are air burst, surface burst, and subsurface burst.

   a. The type of burst that would create the greatest ground shock is the _____ burst.

   b. The type of burst that would create a serious fallout problem over the greatest area is the _____ burst.

   c. The type of burst that creates damage to the most extensive area is the _____ burst.

Check for correct answers by turning to page 35.

Answers to questions on page 34 are as follows. If you miss an answer, the page number indicates the page to return to for review.

1.	Nuclear weapons.	Page 3
2.	Nuclear	Page 8
3.	A thousand or one thousand.	Page 11
4.	A million or one million	Page 11
5.	Fusion - Fission	Page 13 and 19
6.	a. Subsurface.	Page 27
	b. Surface.	Page 31
	c. Air.	Page 25

If you missed more than one question, review the pages where you made an error and then proceed to Section II.

If you had a perfect score, or missed one question, proceed to Section II, page 36.

SECTION II

You did well on Section I. We understand what a nuclear device is, now let's look at blast and fire effects.

ZONES OF DAMAGE (BLAST)

The area of damage is a direct result of:

1. Yield of the weapon.
2. Type of explosion (air, surface, or subsurface burst).
3. Type of construction of buildings and facilities in the target area.

Severe damage is defined as structural damage to an extent requiring the building to be torn down. It cannot be repaired.

Moderate damage is defined as structural damage to an extent that the building can be repaired.

Light damage is defined as broken windows, shutters blown off, doors blown in, shingles blown from roof. This damage might be associated with the type of damage caused by strong winds.

If the damage to a frame dwelling included broken windows, doors blown in, shingles blown from the roof and the house shifted approximately one foot from its foundation, we would define this type of damage as:

a. Light damage - Turn to page 45
b. Severe damage - Turn to page 46
c. Moderate damage - Turn to page 47

You believe that a surface or subsurface burst would create a greater area of blast damage. Not true.

Return to Section I and review the section on types of bursts and their effects.

Correct. A surface burst or a subsurface burst would produce a smaller blast damage area. As a generalization a surface burst would result in approximately a 40% reduction in the blast effects ra .s.

All of the distances indicated on Chart A, page 60, are for a level area. Buildings, hills, mountains, and other barriers would reduce the area of blast.

Complete the following statement:

A 20 MT surface burst would produce moderate damage to an apartment house approximately _____miles from the point of detonation.

1. 6.4 - Turn to page 51.
2. 11.0 - Turn to page 52.
3. 10.0 - Turn to page 53.

Your answer: People sheltered in community shelters would have some protection against blast. We heartily agree with your choice.

Refer to Chart A, page 60, and observe the blast damage radii created by an air burst of 1 MT, 10 MT and 20 MT on three types of structures.

Observe the radii of severe damage created by a 1 MT weapon, 10 MT and 20 MT weapons on an apartment house -- 3.2 miles for a 1 MT weapon, 6.9 miles for a 10 MT weapon, and 8.7 miles for a 20 MT weapon. Note the face that a 10 MT weapon is ten times more powerful than a 1 MT weapon, but the radius of severe damage is only slightly more than twice as great. The areas of damage can be compared by using the formula $A = \pi r^2$. By substituting in the formula, we can compare the areas of severe damage on apartment houses which were produced by a 1 MT and a 10 MT weapon.

For the 1 MT weapon: $A = 3.14 \times (3.2)^2 = 3.14 \times 10.24 =$ 32 sq. mi.

For the 10 MT weapon: $A = 3.14 \times (6.9)^2 = 3.14 \times 47.61 =$ 149 sq. mi.

This shows that a 1 MT weapon will produce 32 square miles of severe damage to apartment house areas, and that a 10 MT weapon will produce 149 square miles of severe damage to apartment house areas.

We observe that the area of damage produced by five 1 MT weapons would be greater than the area of damage produced by one 10 MT weapon. Weapons larger than 20 MT have been developed and could be used, but the cost of production and the problems of delivery would make it less practical at this time. It would be more practicable to use two or more smaller weapons.

Using Chart A, answer the following:

A 1 MT air burst would cause light damage to all buildings ten miles from the point of detonation.

What size weapon would produce moderate damage to an apartment house located ten miles from the point of detonation?

1. 1 MT - Turn to page 42.
2. 20 MT - Turn to page 43.
3. 10 MT - Turn to page 44.

You selected the answer: People sheltered in community shelters would have COMPLETE protection against blast. We defined severe damage as that type of damage that caused structural damage to the extent that the building must be torn down. In each definition of damage, we defined the smallest amount of damage that would be classified in that category. Severe damage includes all damage from the point where there is structural damage to an extent that the building would have to be torn down to complete obliteration of the building. In the event of a surfact burst, there is actually a crater formed at the point of detonation and any structure on the surface at this location would be obliterated along with its occupants. The shelter program does not provide complete protection against blast. The objective of the shelter program is to provide protection against fallout and the blast protection that is provided is due to the type of buildings where community shelters are located.

Protection against fallout could save approximately 40 million lives.

Try again:

People sheltered in community shelters would:

1. Have some protection against blast. - Turn to page 39.
2. Have no protection against blast. - Turn to page 41.

Your answer indicates that you believe that community shelters would provide NO protection against blast. Community shelters are often referred to as fallout shelters and they are not blast proof shelters, but they do provide some protection against blast. We cannot agree with you that they provide NO protection. A person sheltered in a reinforced concrete factory building, an office building, or an apartment house (typical locations of community shelters) would surely have more protection against blast than a person exposed in the open.

Try again:

People sheltered in community shelters would:

1. Have complete protection against blast. - Turn to page 40.
2. Have some protection against blast. - Turn to page 39.

Your answer: 1 MT. You failed to read the chart correctly. A 1 MT explosion would cause moderate damage out to 3.9 miles for an apartment house. Light damage would result for all buildings at this distance. The question asked for the weapon that would produce MODERATE damage to an APARTMENT HOUSE.

Return to page 39 and try again.

Your answer: A 20 MT explosion will produce moderate damage to an apartment house ten miles from the point of explosion. We agree. A 20 MT air burst will produce moderate damage to an apartment house from 8.7 miles to 10.6 miles.

Chart A, page 60, indicates light damage for all buildings. Windows in apartment houses break as easily as windows in private dwellings. Light damage is roughly equal for all buildings.

The civil defense shelter program was developed to protect the population against fallout, but a close look at Chart A will indicate that some blast protection is also provided. Most shelters will be located in apartment houses, office buildings, factories, or the basement of homes. All of these shelters provide better blast protection than the frame house.

Chart A shows the radii of blast damage from an air burst. Select the correct statement:

1. A surface or subsurface burst would create a greater radius of blast damage. - Turn to page 37.
2. A surface or subsurface burst would create a lesser radius of blast damage. - Turn to page 38.

You say a 10 MT weapon will produce moderate damage to an apartment house. Not quite. A 10 MT weapon would produce moderate damage to an apartment house out to 8.4 miles, therefore your answer is incorrect.

Return to page 39 and try again.

You selected light damage as your answer. We don't agree.

We stated that the damage included broken windows, doors blown in, shingles blown from roof, and the house shifted approximately one foot from its foundation. The damage caused by the shifting of the house one foot from its foundation would be structural damage that could be repaired and would be classified as moderate damage. In the case of severe, moderate and light damage, windows would probably be broken, shingles torn from the roof, etc. We would consider the most serious type of damage as the type to be reported. In this situation, the most serious type of damage is the damage to the house as a result of being moved from its foundation.

Return to page 36 and select a better answer.

You selected severe damage as your answer. We disagree.

Severe damage is that type of damage that requires the building be torn down. In this situation, the damage described does not indicate that the building cannot be repaired. Since the building can be repaired, the damage cannot be defined as greater than moderate.

Return to page 36 and select a better answer.

You selected moderate damage. We agree. This building has some structural damage that must be repaired. The building must be replaced on its foundation, but it can be repaired. It also has more damage than is defined as light damage. Go on.

The present Civil Preparedness Program is a fallout shelter oriented program. The objective of the program is to provide a shelter for each citizen. Most of these shelters are located in basements and core areas of buildings.

People sheltered in the core of a building in an area of light damage, broken windows, etc., will be provided protection against the flying glass by the inner walls of the building. If they are in a basement, there are usually few, if any, windows which could be broken. As a result, the number of casualties from blast in an area of light damage would be very small.

In an area of moderate damage, the building will remain standing, and can be repaired. People located in basements of core areas would have a high survival potential.

People sheltered in community shelters would:

1. Have some protection against blast. - Turn to page 39.
2. Have complete protection against blast. - Turn to page 40.
3. Have no protection against blast. - Turn to page 41.

You read the chart wrong. A 10 MT weapon could produce fires at a greater distance than 9.6 miles.

Turn to page 51 and try again.

You read the chart wrong. A 10 MT weapon would NOT produce fires as far out as 26 miles from the point of detonation.

Turn to page 51 and try again.

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Your answer: 20.6 miles. Good. Remember this is the area of POSSIBLE fires. The area of fire might be considerably less, due to cloudy skies, moist air, haze or hills and buildings obstructing the direct thermal radiation.

Within the area of possible fires, it is important to realize that entire buildings would not ignite instantaneously. Fires would be started by kindling fuels such as papers, trash, curtains, etc., exposed to the direct thermal radiation. These fires could build up and spread, and may finally engulf the entire building if nothing is done to extinguish the kindling fires. The shelter system provides some protection against this problem by organizing fire teams for each building where a shelter is located. These fire teams could extinguish the fires in their buildings shortly after bomb detonation, and thus prevent many buildings from burning.

If we assume a 10 MT air burst, we can assume the following fire situation at 20.6 miles from ground zero. (Refer to Chart A.)

1. A solid wall of fire. - Turn to page 54.
2. All buildings on fire. - Turn to page 55.
3. Possible fires. - Turn to page 56.
4. Most buildings on fire. - Turn to page 57.

You selected 6.4 miles. Good. We agree that a surface burst generally produces less blast effects radius than an air burst.

THERMAL RADIATION

One of the important differences between a nuclear and a conventional high-explosive weapon is the large proportion of the energy of a nuclear explosion which is released in the form of thermal (heat) radiation.

Although blast is responsible for most of the destruction caused by a nuclear air burst, thermal radiation will contribute to the overall damage by igniting combustible materials and thus starting fires in buildings or forests.

Chart A indicates the radius of possible fires for a 1 MT, 5 MT, and 20 MT weapon. You will note the possible fire radius is slightly less than the radius of light damage. These radii would be considerably less for a surface burst.

Assuming a 10 MT air burst, it would be possible to have fires out as far as:

1. 9.6 miles - Turn to page 48.
2. 26.0 miles - Turn to page 49.
3. 20.6 miles - Turn to page 50.

Your answer: A 20 MT surface burst would produce moderate damage to an apartment house approximately 11.0 miles from the point of detonation. You erred. It appears as if you took 40% of 18.4 miles, the extent of damage for a wood house. We asked for the damage to an apartment house.

Return to page 38 and try again.

Your answer 10.6 miles. This would be the correct answer for an air burst, but the question asked for the moderate damage caused by a surface burst.

A surface burst produces less area of damage than an air burst. A surface burst would result in approximately 40% reduction in the blast effects radius.

Return to page 38 and try again.

You selected a solid wall of fire. We disagree with you. At 20.6 miles from the point of detonation we could have possible fires. There is a great difference between an area of possible fires and a solid wall of fire. Many buildings will be fire resistant, and be capable of withstanding a much higher amount of thermal radiation. Good fire housekeeping will greatly reduce the fire hazard by eliminating the highly combustible materials from the direct rays of the heat. Shelter fire teams will be able to extinguish many fires before they become serious. Remember this was an air burst, and there is no fear of residual radiation (fallout). Even in the event of a surface burst there will be at least 30 minutes in which to put out fires. A surface burst would not produce possible fires at this distance.

Return to page 50, read the information and try again.

You say all buildings would be on fire. We can't agree with that choice.

Fires are POSSIBLE at this distance but there are several situations that would reduce this possibility. Good fire housekeeping would reduce the probability by removing the highly combustible materials. Weather could seriously diminish the fire potential. Obstructions, such as hills and buildings could also reduce the possibility of fires. Fire fighting actions by shelterees could prevent the building from igniting. These and many other possibilities could prevent all buildings from igniting at 20.6 miles from the point of detonation.

Return to page 50, read the information and try again.

Your answer: Possible fires. We agree. Fires are POSSIBLE AT THIS DISTANCE, but there are several situations that would reduce this possibility. Good fire housekeeping, fog, rain, haze, dust and obstructions such as hills and buildings could reduce the possible area of fire.

Turn to page 58 for review.

You selected the answer: Most buildings on fire. We can't agree with that choice.

Fires are POSSIBLE at this distance, but there are several situations that would reduce this possibility. Good fire housekeeping would reduce the probability by removing the highly combustible materials. Weather could seriously diminish the fire potential. Obstructions, such as hills and buildings could also reduce the possibility of fires. Fire fighting actions by shelterees could prevent the building from igniting. These and many other possibilities could prevent all buildings from igniting at 20.6 miles from the point of detonation.

Return to page 50, read the information and try again.

Now, let's review.

1. Structural damage to an extent that the building can be repaired is defined as:

   a. Light damage.

   b. Moderate damage.

   c. Severe damage.

2. People sheltered in community shelters would have _____ protection against blast. (Select the word that completes this statement.)

   a. Complete.

   b. Some.

   c. No.

3. A surface burst will create a greater area of blast damage.

   a. The above statement is true.

   b. The above statement is false.

4. In the area of light damage, we would expect:

   a. A solid wall of fire.

   b. All buildings on fire.

   c. Most buildings on fire.

   d. Possible fires.

Check for correct answers by turning to page 59.

Answers to questions on page 58 are as follows. If you miss an answer, the page number indicates the page to return to for review.

1.	b - Moderate damage.	Page 36
2.	b - Some.	Page 47
3.	b - False.	Page 38
4.	d - Possible fires.	Page 50

If you missed a question, review the pages where you made an error and then proceed to Section III, page 61.

If you had a perfect score, proceed to Section III.

CHART A

RADII OF DAMAGE FOR AIR BURSTS

	1 MT	10 MT	20 MT
SEVERE DAMAGE (RADII)			
WOOD HOUSE	5.8 miles	12.5 miles	15.7 miles
APARTMENT HOUSE	3.2	6.9	8.7
REINFORCED CONCRETE BLDG.	1.4	3.0	3.8
MODERATE DAMAGE (RADII)			
WOOD HOUSE	6.8	14.6	18.4
APARTMENT HOUSE	3.9	8.4	10.6
REINFORCED CONCRETE BLDG.	1.7	3.7	4.6
LIGHT DAMAGE (RADII)			
ALL BUILDINGS	10.0	21.5	27.1
POSSIBLE FIRES	9.6	20.6	26.0

SECTION III

RADIATION

In a surface burst, large quantities of earth or water enter the fireball at an early stage and are fused or vaporized. When sufficient cooling has occurred, the fission products and other radioactive residue become condensed in and on the surface materials drawn into the cloud. As the violent disturbance due to the explosion subsides, the contaminated particles and droplets gradually fall back to earth. The effect is referred to as the "fallout." It is the radioactive material associated with the fallout which decays over a long period of time, that is the main source of the residual nuclear radiations.

Select one of the following statements as the correct statement about fallout, and turn to the page indicated by your selection.

1. In an air burst, large quantities of earth, etc., fuse with the fission products and other radioactive residue to produce "fallout." Page 62

2. In a surface burst, large quantities of earth, etc., fuse with the fission products and other radioactive residue to produce "fallout." Page 63

You selected the answer: In an air burst, large quantities of earth, etc., fuse with the fission products and other radioactive residue to produce "fallout." We caught you napping. If you turn back to page 1, you will find the two answers are the same except for the type of explosion. You chose the air burst. In an air burst there is very little debris to fall back to earth as fallout. The only debris available is from the weapon itself, therefore, there is limited material to mix with the fission products. In a surface burst there are tons and tons of earth, water, etc., to mix with the fission products. Some of this material is vaporized and fused with the fission products during the cooling process. There are, therefore, tons and tons of material which must return to earth as fallout.

An air burst produces very little fallout, and is not a civil defense fallout problem, A surface burst produces tons and tons of debris and creates a tremendous problem from fallout.

Turn to page 63.

You selected the answer: In a surface burst, large quantities of earth, etc., fuse with the fission products and other radioactive residue to produce "fallout." We agree. You are off to a good start. An air burst would not produce a large enough quantity of earth and water, etc., to produce local fallout. Proceed.

It takes time for fallout to drop from the nuclear cloud, even close to the burst, and the size of the particles is an important factor in determining the rate of its return to earth.

Significant amounts of fallout begin to arrive in the immediate vicinity outside a blast area about 30 minutes after an explosion. People some 20 miles away may have an hour to seek protection from the fallout. At a distance of 100 miles, the fallout may not arrive for four hours or more. The fallout will continue to cover an increasingly larger area, and may eventually cover several thousand square miles. Some areas that will receive fallout might not get it until 24 hours or more after the explosion, and lighter deposits of fallout may continue for many hours afterwards. Outside of areas affected by blast and heat then, the earliest and most immediate serious danger following a nuclear attack could be from local fallout.

Which of the following statements best describes what we have discussed this far?

1. Fallout from a surface burst will cover a large area of land. Page 67

2. An air burst produces fallout close to the explosion in about 30 minutes. Page 68

3. A surface burst produces fallout over an area about 100 miles downwind in about 30 minutes. Page 69

Your answer: Fallout distribution is determined primarily by surface winds. You aren't paying attention. You have to do more than simply read this material. You have to pay attention. We said that fallout distribution is determined primarily by high altitude winds. If the nuclear debris is carried up in the nuclear column to a height of 60,000 to 80,000 feet and is then dropped to earth, it must travel through all the layers of air from 80,000 feet to the surface. Winds at different levels often travel in different directions from the surface winds. Therefore, the surface winds do not determine the direction of fallout. The combination of all the winds at all levels from the cloud to the surface determine the area of fallout.

Return to page 67 and select another answer.

Your answer: If the surface winds are known, an accurate prediction can be made as to when fallout will arrive at a particular location. You aren't reading carefully. Fallout distribution is determined primarily by high altitude winds. If the nuclear debris is carried up in the nuclear column to a height of 60,000 to 80,000 feet and is then dropped to earth, it must travel through all the layers of air from 80,000 feet to the surface. Winds at different levels often travel in different directions from the surface winds. Therefore, the surface winds do not determine the direction of fallout. The combination of the winds at all levels from the cloud to the surface affect the direction of fallout.

The second error is that of selecting an answer that states an accurate prediction can be made. It is impossible to determine exactly how long a particle will remain in any layer of the atmosphere. Therefore, we can only make a reasonable estimate of the direction where fallout will be deposited. We cannot make an accurate prediction. The only method of determining how much fallout there will be at any specific location is to measure the radiation at that point with an instrument when it has arrived.

Return to page 67 and select another answer.

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Your answer: The time of fallout arrival at any point is determined by the wind at various altitudes and the height of the explosion. Good. You are paying attention.

Civil defense is concerned with local fallout. There is worldwide fallout from any nuclear explosion which creates a long-term health problem, but does not require sheltering the population. We will only concern ourselves with close-in or local fallout.

The region of severe local fallout lies downwind from the point of burst. It is impossible to predict with accuracy how large this area will be or what shape it will take because so many conditions can affect it. The area of severe local fallout might stretch five miles or more upwind of ground zero and 150 to 200 or more miles downwind depending on the strength of the wind and the bomb yield.

Which statement best describes local fallout?

1. Local fallout is that fallout which is deposited within 5 miles of the explosion. Page 70

2. Local fallout is that fallout which is deposited within 50 miles of the explosion. Page 71

3. Local fallout is that fallout which is deposited within 100 miles of the explosion. Page 72

4. None of the above. Page 73

Your answer: Fallout from a surface burst will cover a large area. We're together on this. An air burst does not produce significant fallout, and the fallout from a surface burst will arrive close to the point of explosion in about 30 minutes.

The time of fallout arrival at various distances and directions from the point of explosion (ground zero) depends on the winds and upon the height of the explosion. Layers of air move in various directions at different heights. Fallout distribution is determined primarily by high altitude winds that often blow in a different direction from the ground level winds.

Select one of the following statements:

1. Fallout distribution is determined primarily by surface winds. Page 64
2. If the surface winds are known, an accurate prediction can be made as to when fallout will arrive at a particular location. Page 65
3. The time of fallout arrival at any point is determined by the wind at various altitudes and the height of the explosion. Page 66

You selected the answer: An air burst produces fallout close to the explosion in about 30 minutes. Be careful. Some of these statements are tricky. An air burst does not produce much fallout since the only material involved is the weapon itself and minute particles in the atmosphere. A surface burst, on the other hand, produces tons and tons of debris. An air burst would not produce early fallout but would produce a small amount of worldwide fallout. In civil defense, we are concerned with the survival problem from local fallout -- not worldwide fallout.

Return to page 63 and select another answer.

You selected the answer: A surface burst produces fallout over an area about 100 miles downwind in about 30 minutes. You are partially correct. You selected a surface burst -- not an air burst. We are happy to see you have that part correct. How about the part of the answer which states that it produces fallout over an area about 100 miles downwind in about 30 minutes? It takes time for the vaporized earth, water, etc., to rise in the nuclear column to 60,000 to 80,000 feet, condense and return to earth. We stated that fallout would arrive in the area immediately outside the blast area in about 30 minutes. It would take much longer to arrive at a point 100 miles downwind of the explosion. The time of arrival 100 miles away is dependent upon the winds from the height of the cloud to the earth. If the winds at 80,000 feet, 60,000 feet and all levels to the surface are constant in one direction and are blowing toward the same direction, then we could divide 100 miles by the speed of the wind and determine approximately when the fallout would arrive at a point 100 miles downwind of the explosion. If the winds were blowing from different directions at various levels, we would have a different problem.

Turn to page 63 and try another answer.

You selected the answer: Local fallout is that fallout which is deposited within 5 miles of the explosion. You could be correct if there was absolutely no wind at any of the various levels of the atmosphere that the debris must travel through. It would also be necessary to have an explosion where the cloud did not grow beyond 5 miles in radius. This is not likely to be the case. Therefore, we disagree with your selection.

Read page 66 again and select another answer.

Your answer: Local fallout is that fallout which is deposited within 50 miles of the explosion. You could be right under certain conditions, but it is not likely that fallout will be deposited within 50 miles of ground zero only. Normally fallout will travel several hundred miles, depending on the height of the cloud, the density of the particles, and the speed of the wind at the various levels that the particles will travel through.

Return to page 66 and select another answer.

Your answer: Local fallout is that fallout which is deposited within 100 miles of the explosion. You are partially right. That fallout which is deposited within 100 miles of the explosion is certainly local fallout, but what about that fallout which is deposited 101 miles away, 200 miles away, or 300 miles away?

Return to page 66 and select another answer.

Your answer: None of the above. You're on the ball. Good. The distribution of fallout is primarily determined by the direction and speed of the wind, particularly those up to 80,000 feet. There are other phenomena that determine the amount and location of local fallout. They are:

1. Power and design of the weapon. Larger weapons will normally produce greater debris and fallout, and there are so-called "clean" and "dirty" bombs. These are relative terms. "Clean" bombs produce less radioactive material than a "normal" weapon and "dirty" weapons produce more.

2. The size, shape and density of the fallout particles will determine how rapidly they return to earth. That is, the heavier particles will return to earth more rapidly than very fine particles and will lead to increased concentrations of fallout in these areas.

3. Rain and snow may wash out the radioactive cloud and concentrate the fallout closer to ground zero.

4. Finally, the nature of the ground surface affects the concentration of fallout. In general, the movement of fallout particles by wind and water is over short distances. The particles become entrapped by vegetation, small scale irregularities in the ground, etc. The movement of fallout particles by wind and water over paved surfaces is probably of greater concern to the urban population.

Turn to page 74.

We might sumarize all that we have discussed by saying there are five basic factors that determine the extent and location of a fallout area:

1. Altitude of burst. Surface burst produces local fallout. An air burst does not produce serious local fallout.

2. Power and design of the weapon. Larger weapons generally produce more radioactive debris.

3. Size, shape and density of the fallout particles. Large, heavy particles would fall more rapidly than light particles.

4. Atmospheric conditions such as air currents and the direction and speed of the winds, particularly those up to perhaps 80,000 feet.

5. Snow and rain would wash out some of the fallout and bring it to earth faster and, therefore, concentrate it over a smaller area.

Determine whether the following is true or false.

The extent and location of a fallout area and the dose rates in that area are easy to forecast preattack.

True - Turn to page 75.

False - Turn to page 76.

You selected True. We can't agree with that answer. We listed five variables on page 14 that affect the extent and location of a fallout area. With five variables to consider, it would be almost impossible to forecast direction and radiation levels for any single location. Our objective is to give a reasonable forecast of the approximate location and time of fallout arrival in downwind areas. This objective will be difficult to obtain postattack, when we can actually determine the exact location of the explosion, the wind direction and velocity and other variables. It will be impossible to obtain this type of information before attack, when the location of the explosion and the size and type of explosion are not known.

Turn to page 76.

You selected False. We agree. Now let's take a look at the composition of this fallout.

Fallout from a nuclear explosion emits beta particles and gamma rays. Beta particles have a range of only 10 to 12 feet in open air but they do not penetrate materials easily. Several layers of clothing can protect the body. If enough fallout remains on exposed skin for some time (hours), the beta particles can cause severe burns. Beta particles can also cause some internal damage if fallout is ingested.

Gamma rays pose the greatest threat since they are extremely penetrating, e.g., up to several hundred feet in air. They may be likened to a kind of invisible light to which all things are partly transparent. In contrast to the thin amount of material needed to stop beta particles, only 50% of the gamma rays are stopped or absorbed by about 2 inches of concrete. In a fallout area, the amount of gamma rays reaching the body can be reduced to acceptable levels by putting enough shielding between a person and the source of radiation. In general, the denser the material, the less thickness is required for shielding. If the shielding is thick enough, and dense enough, it would cut gamma radiation exposure to such a low level that it can do little harm.

Select one:

1. Beta particles will travel through about ten feet of concrete. Page 81

2. About half the gamma rays will pass through two inches of concrete. Page 82

3. Beta particles pose a greater threat than gamma rays. Page 83

Your answer: The cellophane bag is contaminated and the apple is radioactive. You are half right. The cellophane bag is contaminated but the apple is not radioactive. This phase of the effects of weapons is an area where we must have complete understanding -- so half right is not good enough.

Let's try explaining that a little better. The only thing that is radioactive is the fallout (dust). All materials that the fallout drops on become CONTAMINATED -- not radioactive. That is, the dust can be removed (DECONTAMINATION) and the article or material will no longer be contaminated. If a person were caught in the open during the period that fallout was being deposited, the dust would fall on the person, CONTAMINATING him. If the person removed the dust from his outer clothing and from his body by washing or brushing (DECONTAMINATION), he would no longer be contaminated. The body would have been exposed to nuclear radiation during this period when the fallout was on him, or near him. The amount of exposure that the person received would depend on the length of time he was EXPOSED to the radioactive material and the rate of exposure to nuclear radiation.

Return to page 82 and try again.

Your answer: The cellophane bag is radioactive and the apple is contaminated. Wrong on two counts.

This is a difficult area to teach, so let me try again. The only thing that is radioactive is the fallout (dust). All materials that the fallout drops on become CONTAMINATED, not radioactive. That is, the dust can be removed (DECONTAMINATION) and the article or material will no longer be contaminated. If a person were caught in the open during the period that fallout was being deposited, the dust would fall on the person, CONTAMINATING him. If the person removed his outer clothing, and removed all the dust from his body by washing or brushing (DECONTAMINATION), he would no longer be contaminated. The body would have been EXPOSED to nuclear radiation during this period when the fallout was on him -- or near him. The amount of exposure that the person received would depend on the length of time he was EXPOSED to the radioactive material and the rate of exposure to the nuclear radiation.

The fallout (dust) is RADIOACTIVE.

The object that the fallout settles on is CONTAMINATED.

During the period that an object is CONTAMINATED or close to fallout, it is EXPOSED to the radiation being emitted by the fallout.

DECONTAMINATION is the process of removing the radioactive material (dust).

Return to page 82. Read the instructions and try again.

Your answer: The cellophane bag is contaminated and the apple is exposed to nuclear radiation. Good. That was a difficult one and we are glad you are still with us. Now, let's consider what happens when we are EXPOSED to nuclear radiation.

When large amounts of nuclear radiation are absorbed by the body in short periods of time, sickness and death may result. Few people get sick who have been exposed to 100 roentgens or less. Exposure to more than 300 roentgens over a period of a few days will cause sickness and may cause death. Death is expected to ensue for almost everyone who receives an exposure of 600 or more roentgens over a period of a few days.

The period of time over which the exposure is received has a tremendous effect on the resulting sickness or death. The above doses refer to short term doses of less than a week. The same exposure received over a lifetime would probably produce NO sickness.

Nuclear radiation kills living cells. As a result, when we are EXPOSED to nuclear radiation, cells of the body are killed. If only a small number of cells are killed (small dose of nuclear radiation), then the body begins replacing these dead cells with new cells and repair takes place. We can then better tolerate additional exposure. This process goes on, even during the time we are being exposed.

Select the best answer:

A person exposed to 600 roentgens:

1. Would be sick and probably die. Page 84
2. Would be sick and would die. Page 85
3. Might be sick and might die. Page 86

Your answer: The fallout is radioactive and the apple is contaminated.

You are half wrong. The apple is NOT contaminated.

The fallout must be on the apple to consider the apple CONTAMINATED. In the situation given, the apple was in a cellophane bag. The bag is contaminated, has the radioactive material resting on it, but the apple is EXPOSED to the gamma rays. If we washed (DECONTAMINATION) the apple and returned it to the contaminated cellophane bag, the apple would continue to be EXPOSED TO RADIATION. If, on the other hand, we washed the cellophane bag and did nothing to the apple, the apple would no longer be exposed to radiation since the radioactive material has been removed from the bag.

Return to page 82 and try again.

Your answer: Beta particles will travel through about ten feet of concrete. You missed the ball. Beta particles will cause severe burns if particles emitting them were permitted to remain on the skin for a considerable time but they can be removed (DECONTAMINATION). In addition, they have little penetrating power, so a small amount of material such as clothing can protect against its harmful effects.

Return to page 76 and try again.

Your answer: About half the gamma rays will pass through two inches of concrete. Good -- let's go further.

Nuclear radiation from fallout can damage living things, but it does not cause an exposed person to become radioactive. Thus, if fallout particles are on the body of a person or animal, instruments may detect nuclear radiation coming from that contamination, but if the fallout particles are removed, no radiation will be detected. The same principle applies to water in closed storage tanks or to food in cans or other closed containers.

If radioactive fallout drops on an object, that object is contaminated. This object is also exposed to the nuclear radiation. If there is some material between the exposed object and the radioactive fallout, then the object is merely exposed to nuclear radiation.

If a can of food were covered with radioactive debris, the can would be contaminated and exposed to nuclear radiation. The food inside the can would be exposed -- not contaminated. The fallout on the can would be radioactive. The food inside the can would not be radioactive or contaminated.

If radioactive fallout drops on the cellophane bag containing an apple, we would say:

(Select one.)

1. The cellophane bag is contaminated and the apple is radioactive. Page 77

2. The cellophane bag is radioactive and the apple is contaminated. Page 78

3. The cellophane bag is contaminated and the apple is exposed to nuclear radiation. Page 79

4. The fallout is radioactive and the apple is contaminated. Page 80

Your answer: Beta particles pose a greater threat than gamma rays.

Hardly. Beta particles do produce severe burns if permitted to remain on the exposed skin for some time, but a thin layer of material, such as our clothing, will provide considerable protection against beta particles.

Return to page 76, read the statement carefully, and select another answer.

Your answer: A person exposed to 600 roentgens would be sick and probably would die. We can't agree with that selection. We didn't intend to be tricky in this question but we did not want to be very exacting. An exposure to 600 roentgens over a short period of time (four days or less) would cause sickness and probable death, but this same amount received over a lifetime would not cause death. We wanted to be sure that you didn't miss this point.

Read page 79 carefully and then select another answer.

Your answer: A person exposed to 600 roentgens would be sick and would die. We're not together on that answer. We'll go over that again.

Six hundred (600) roentgens received over a FEW DAYS will cause sickness and MAY cause death. Even a short term dose of 600 roentgens might not cause death. This same amount received over a lifetime would probably not produce sickness.

The time during which the total dose is received is an important element in the effect produced. We must consider both the total exposure (dose) and the period of time during which this dose was received.

Return to page 79 and read the information carefully and then select another answer.

Your answer: A person exposed to 600 roentgens might be sick and might die. We agree.

Persons exposed to large amounts of nuclear radiation over a short period of time will develop radiation sickness. Radiation sickness is neither contagious nor infectious. A person cannot "catch it" from others. People or animals suffering from radiation sickness can be helped without fear of "catching" radiation injury or sickness from them.

The symptoms of radiation sickness are nausea and vomiting, which may appear in the first day or so; then about a week may pass before other symptoms appear. These later symptoms are loss of weight, loss of appetite, bleeding, discolored spots on the skin, paleness, redness, and general discomfort.

It is important to remember that symptoms such as nausea and vomiting may also appear in people who do not have radiation sickness. These symptoms may be observed in persons subject to extreme anxiety and emotional stress.

Proceed to page 87.

Now, let's review.

1. Select the correct statement.

   a. An air burst produces fallout close to the explosion in about 30 minutes.

   b. Fallout from a surface burst will cover a large area of land.

   c. A surface burst produces fallout over an area about 100 miles downwind in about 30 minutes.

2. Select the correct statement.

   a. The time of fallout arrival at any point is determined by the wind at various altitudes and the height of the explosion.

   b. Fallout distribution is determined primarily by surface winds.

   c. If the surface winds are known, an accurate prediction can be made as to when fallout will arrive at a particular location.

3. Which statement best describes local fallout?

   a. Fallout that is deposited within 5 miles of the explosion.

   b. Fallout that is deposited within 50 miles of the explosion.

   c. Fallout that is deposited within 100 miles of the explosion.

   d. None of the above.

4. The extent and location of a fallout area and the levels of radiation in that area are easy to forecast preattack.

   a. The above statement is true.

   b. The above statement is false.

5. Select the correct statement.

   a. Beta particles will travel through about ten feet of concrete.

   b. About half the gamma rays will pass through two inches of concrete.

   c. Beta particles pose a greater threat than gamma rays.

6. If radioactive fallout lands on the roof of a building, we would say the roof was _____. (Select one or more of the following choices.)

   a. Radioactive.

   b. Contaminated.

   c. Exposed.

   d. All of the above.

7. A person exposed to 600 roentgens in a period of two days:

   a. Would be sick and probably die.

   b. Might be sick and might die.

   c. Would be sick and would die.

Check for correct answers on page 89.

Answers to the questions on pages 87 and 88 are as follows. If you miss an answer, see the pages listed below for review.

1.	b	Page 63
2.	a	Page 67
3.	d	Page 66
4.	b	Page 74
5.	b	Page 76
6.	b and c	Page 82
7.	a	Page 79

Proceed to Section IV, page 90.

SECTION IV

PROTECTIVE MEASURES AGAINST RADIATION

Protection from external radiation exposure is a combination of three things:

1. Time.
2. Distance (decontamination, movement, area).
3. Shielding (shelter).

In a fallout area, shielding is the only dependable means of protection. People within a well-stocked shelter have placed mass and distance between themselves and the source of nuclear radiation, and they should remain surrounded by this mass until the radiation level has decayed enough to permit activities outside of the shelter.

People will be notified by the Emergency Broadcast System, messenger, or other means of communication when it is safe to leave shelter.

Turn to page 91 for further information.

TIME

Exposure rates or radiation levels from fallout decrease with time -- that is, the exposure rate -- as measured in roentgens per hour, drops lower and lower. This falling off is known as radioactive decay.

The "half life" of a radioactive material (isotope) is the time required for a given amount of it to lose half of its original activity. For instance, a form of cobalt (cobalt 60) has a half life of about 5 years. Suppose that we measured the radiation level 12 inches from a given amount of that radioactive material, and it was 200 R/hr. If repeated 5 years later, it would have fallen to about 100 R/hr.; 5 years after that it would have fallen to about 50 R/hr.

YEAR	EXPOSURE RATE MEASUREMENT
1965	200 R/hr
1970	100 R/hr
1975	50 R/hr

What would the measurement be in an additional 5 years (1980)?

1. If your answer is 25 R/hr, turn to page 92.
2. If your answer is 5 R/hr, turn to page 93.
3. If your answer is other than above, turn to page 94.

Your answer: You said the measurement in 5 years would be 25 R/hr. You are correct.

Each radioactive isotope has a different half life, and this ranges from a small fraction of a second to billions of years. Fallout is composed of a combination of many radioactive elements (isotopes).

The mixture of isotopes formed after a nuclear burst -- the mixture that makes up fallout -- is so complex that it is not possible to calculate the exact decay rate. However, from experimental measurements, a rough approximation indicates that for each sevenfold increase in time, there is a tenfold decrease in the exposure rate. In general, the exposure rate at 49 hours after the explosion will have dropped to about 10 percent of its value at 7 hours.

If the exposure rate at 7 hours after explosion was 400 R/hr, the exposure rate at 49 hours after explosion would be 40 R/hr.

If the exposure rate 7 hours after explosion was 300 R/hr, what would the exposure rate be at 49 hours after explosion?

1. If your answer is 300 R/hr, turn to page 102.
2. If your answer is 3 R/hr, turn to page 103.
3. If your answer is 30 R/hr, turn to page 104.

Your answer: You said the measurement would be 5 R/hr in 5 years. Your answer is wrong. Every 5 years the radiation level of cobalt 60 decreases to one-half of the radiation level 5 years previous. The previous radiation level was 50 R/hr.

If the radiation level of cobalt 60 is 50 R/hr now, what will the radiation level be 5 years from now?

1. If your answer is 25 R/hr, turn to page 92.
2. If your answer is 5 R/hr, turn to page 95.

You did not select the correct answer. Return to page 91. Read the information carefully and try again.

Your answer: 5 R/hr. Wrong.

Return to page 91 and start again.

Your answer: You selected 14 hours. Your answer is wrong. You indicate a decrease for every seven hours. The decrease should be for every sevenfold increase of time. The previous time should be multiplied by seven, not two as you have done.

Return to page 101 and try again.

Your answer: 49 hours. You are correct. You understand that for every sevenfold increase in time, the radiation level decreases to approximately one-tenth of its previous level. Good.

The 7/10 rule of thumb states: "For each sevenfold increase in time, the exposure rate of the mixture found in fallout drops to about one-tenth of its former value." Using this 7/10 rule we can determine the estimated exposure rate at any sevenfold increase in time provided we know the exposure rate at some specific time after explosion. If we know the exposure rate at 3 hours after explosion, we could determine the approximate exposure rate at 21 hours, 147 hours, and 1029 hours.

Complete the following chart:

Time After Explosion	Exposure Rate
5 hours	300 R/hr
_____	Approximately 30 R/hr
_____	Approximately 3 R/hr

1. If your answer is 35 hours and 245 hours, turn to page 106.
2. If your answer is 50 hours and 500 hours, turn to page 107.
3. If your answer is 10 hours and 15 hours, turn to page 108.

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Your answer: You selected 70 hours. Did you really mean that? Aren't you a bit confused? You increased the time tenfold. Time is always a sevenfold change for this rule.

Return to page 101 and try again.

Your answer: You selected 300 R/hr. This indicates an increase in the exposure rate with the passing of time. Radiation levels decay or decrease with the passage of time. Your answer is wrong.

Each kind or form of radioactive material (isotope) has a different half life, and this ranges from a small fraction of a second to billions of years. Fallout is composed of a combination of many radioactive materials (isotopes).

The mixture of isotopes formed after a nuclear burst -- the mixture that makes up fallout -- is so complex that it is not possible to calculate the exact decay rate. However, from experimental measurements, a rough approximation indicates that for each sevenfold increase in time, the radioactivity of the mixture found in fallout drops to about one-tenth of its former value. In general, the activity of the radioactive material at 49 hours after the explosion will have dropped to about 10 percent of its rate at 7 hours.

If the exposure rate at 7 hours after explosion was 400 R/hr, the exposure rate at 49 hours after explosion would be approximately 40 R/hr.

If the exposure rate 7 hours after explosion was 300 R/hr, what would be the approximate exposure rate at 49 hours after explosion?

1. If your answer is 300 R/hr, turn to page 102.
2. If your answer is 3 R/hr, turn to page 103.
3. If your answer is 30 R/hr, turn to page 104.

Your answer: You selected 3/10 R/hr. This would be a decrease to 1/100th of the exposure rate at the previous sevenfold time period. Your answer is wrong.

Each radioactive isotope has a different half life, and this ranges from a small fraction of a second to billions of years. Fallout is composed of a combination of many materials (isotopes).

The mixture of isotopes formed after a nuclear burst -- the mixture that makes up fallout -- is so complex that it is not possible to calculate the exact decay rate. However, from experimental measurements, a rough approximation indicates that for each sevenfold increase in time, the radioactivity of the mixture found in fallout drops to about one-tenth of its former value. In general, the activity of the radioactive material at 49 hours after the explosion will have dropped to about 10 percent of its rate at 7 hours.

If the exposure rate at 7 hours after explosion was 400 R/hr, the exposure rate at 49 hours after explosion would be approximately 40 R/hr.

If the exposure rate 7 hours after explosion was 300 R/hr, what would be the approximate exposure rate at 49 hours after explosion?

1. If your answer is 300 R/hr, turn to page 102.
2. If your answer is 3 R/hr, turn to page 103.
3. If your answer is 30 R/hr, turn to page 104.

Your answer: You selected 3 R/hr. You observed that the chart indicates sevenfold increases of time in the first column and exposure rate decreases to one-tenth in the second column. You are correct.

Complete the following chart using the 7/10 rule of thumb:

Time After Explosion	Exposure Rate
1 Hour	3000 R/hr
7 Hours	Approximately 300 R/hr
? Hours	Approximately 30 R/hr

1. If your answer is 14 hours, turn to page 96.
2. If your answer is 49 hours, turn to page 97.
3. If your answer is 70 hours, turn to page 98.

Your answer: You selected 300 R/hr. This is the same exposure rate as at H + 7 hours. You did not allow for decay. Your answer is wrong.

For each sevenfold increase in time, the exposure rate of the mixture found in fallout drops to about one-tenth of its former value. If the exposure rate at one hour after explosion was 3000 R/hr, then at seven hours after explosion (1 x 7) it would be 300 R/hr (3000 divided by 10); at 49 hours (7 x 7), it would be 30 R/hr (300 divided by 10).

If the exposure rate level at one hour after explosion is 3000 R/hr, what would be the approximate exposure rate at 49 hours after explosion?

1. If your answer is 3 R/hr, turn to page 94.
2. If your answer is 30 R/hr, turn to page 104.
3. If your answer is 3000 R/hr, turn to page 105.

Your answer: You selected 3 R/hr. Your answer is wrong. You made a mathematical error or you misunderstood the rule.

For each sevenfold increase in time, the exposure rate of the mixture found in fallout drops to about one-tenth of its former value. If the exposure rate at one hour after explosion was 3000 R/hr, then at seven hours after explosion (1 x 7), it would be 300 R/hr (3000 divided by 10); at 49 hours (7 x 7), it would be 30 R/hr (300 divided by 10).

If the exposure rate at one hour after explosion is 4000 R/hr, what would be the approximate exposure rate at 7 hours after explosion?

1. If your answer is 40 R/hr, turn to page 94.
2. If your answer is 400 R/hr, turn to page 104.

Your answer is correct. Proceed.

The rule of thumb we have been working with is commonly referred to as the 7/10 rule of thumb. The rule states: "For each sevenfold increase in time, the exposure rate of the mixture found in fallout drops to about one-tenth of its former value."

Complete the following table by use of the 7/10 rule of thumb:

Time After Explosion*	Exposure Rate*
1 Hour	3000 R/hr
7 Hours	300 R/hr
49 Hours (2 days)	30 R/hr
343 Hours (2 weeks)	

1. If your answer is 300 R/hr, turn to page 99.
2. If your answer is 3/10 R/hr, turn to page 100.
3. If your answer is 3 R/hr, turn to page 101.

* NOTE: This theoretical table assumes that all the fallout from a weapon has been deposited at one hour after the explosion and that no additional fallout affects the reading at a later time. If an actual reading of 3000 R/hr were obtained at H + 1 it probably would continue to rise until all the fallout from that weapon were on the ground. If a new weapon detonation created fallout in the area of concern it would, of course, invalidate prior 7/10 rule of thumb calculations.

You selected the wrong answer. Return to page 91 and start again.

Your answer: You selected 35 hours and 245 hours. Starting at 5 hours, these are sevenfold increases in time. You are correct. You have the basic theory. Let us try a more difficult chart.

Fill in the missing time or intensity in the following sequence:

Time After Explosion	Exposure Rate
2 Hours	3000 R/hr
14 Hours	____ R/hr
_____	30 R/hr
686 Hours	____ R/hr

Turn to page 109 for correct answers.

Your answer: You selected 50 hours and 500 hours. This would be a tenfold increase of time. You are wrong.

The rule states for each sevenfold increase in time the exposure rate drops to about one-tenth of its former value. You increased the time by tenfold.

Return to page 97 and try again.

Your answer: You selected 10 hours and 15 hours. You are confused. DO NOT PROCEED. Return to page 91 and read the instructions carefully.

Time After Explosion	Exposure Rate
2 Hours	3000 R/hr
14 Hours	300 R/hr
98 Hours	30 R/hr
686 Hours	3 R/hr

If you have completed the chart correctly, congratulations. You understand the 7/10 rule of thumb. Proceed to page 110 for final review. If you failed to complete the chart correctly, return to page 97 for review.

REVIEW TEST FOR 7/10 RULE OF THUMB

The measured exposure rates at a fixed location at the following times were:

TIME	EXPOSURE RATE
H+1	3000 R/hr
H+2	1300 R/hr
H+3	800 R/hr
H+4	560 R/hr
H+5	420 R/hr
H+6	350 R/hr

What would be the estimated exposure rates at the following times:

TIME	EXPOSURE RATE
H+7	
H+14	
H+21	
H+28	
H+35	
H+42	

Turn to page 111 to check answers.

TIME	EXPOSURE RATE
H+7	300 R/hr
H+14	130 R/hr
H+21	80 R/hr
H+28	56 R/hr
H+35	42 R/hr
H+42	35 R/hr

If your answers disagree with the above answers, return to page 110 and try again. If you disagree on the second try, return to page 91.

If your answers agree with the above answers, you have done very well.

Turn to page 112.

DISTANCE

Distance is an effective method of reducing the rate of exposure to nuclear radiation. It can be accomplished in two ways:

1. Move the radioactive material from the people.
2. Move the people from the radioactive material.

Movement of the radioactive material is known as decontamination, and involves all methods of moving the radioactive material from a place where it is harmful to a location where it is harmless or less harmful. We decontaminate personnel by removing the radioactive material from their clothing and person, either by brushing or washing, and removing the dirt or radioactive material to a location where it will have little or no effect on people (outside the shelter area). We can also remove the radioactive material from the roofs of buildings, and from the immediate area surrounding a building to reduce the inside exposure rate.

The protection provided at selected facilities can be increased by using this principle. Shelters are often located in the core area of buildings. In this way they keep the people a distance away from the radioactive material. The distance from the radioactive material to the people in the shelters is increased, providing additional protection. The thickness of the building walls, plus this additional distance will often provide adequate protection.

Turn to page 113.

SHIELDING

Another method of protection against the hazards of fallout is to place a barrier between the fallout field and the individual. This is termed "barrier shielding."

If a shield is placed between the fallout and an individual, there will be a reduction in the exposure. The greater the mass of the shield, the greater the reduction in the exposure.

Comparative thickness of materials which offer about the same degree of shielding are:

1. Lead - 2.5 inches
2. Steel - 7 inches
3. Concrete - 24 inches
4. Earth - 30 inches
5. Water - 50 inches
6. Wood - 90 inches

Using the above table as a guide, determine which of the following would provide the greatest amount of protection against Gamma radiation.

a. 12 inches of concrete - Turn to page 117.

b. 1 inch of lead - Turn to page 118.

c. 60 inches of wood - Turn to page 119.

FINAL REVIEW

(Use Answer Sheet provided on page 116. Do not write on these pages.)

Determine if the following statements are True or False.

1. A megaton equals a million tons of TNT.

2. Nuclear explosions can be millions of times more powerful than conventional weapons.

3. Fallout deposited 100 miles downwind of the explosion would be referred to as local fallout.

4. In the area of moderate damage, the building will remain standing and can be repaired. People located in basements or core areas would have a high survival potential.

5. In an air burst, large quantities of earth, etc., fuse with the fission products and other radioactive residue to produce "fallout."

6. A megaton equals a thousand kilotons.

7. Nuclear explosions will ignite fires beyond the area of light damage.

8. Nuclear detonations produce heat, blast, and radiation.

9. The fission process releases greater energy than the fusion process.

10. Gamma rays pose a serious threat since they are extremely penetrating; e.g., up to several hundred feet in air.

11. A kiloton equals a thousand tons of TNT.

12. In a nuclear detonation, about 15% of the total energy is dissipated in the form of nuclear radiations.

13. Light damage from a nuclear detonation is defined as broken windows, shutters blown off, doors blown in, and shingles blown from the roof.

14. Preparation for a missile attack, using nuclear warheads, would provide sufficient preparation to cope with a conventional attack.

15. In the area of light damage, there would be a minimum of 30 minutes before the arrival of fallout.

16. Conventional weapons are accompanied by highly penetrating, harmful, but invisible nuclear radiations.

(Continued on page 115.)

Select the correct answer for the following:

17. If the exposure rate 7 hours after explosion was 300 R/hr, what would the exposure rate be at 49 hours after explosion (approximate)?

a. 300 R/hr b. 30 R/hr c. 3 R/hr

18. The type of burst that produces the greatest area of blast is:

a. Surface burst. b. Subsurface burst. c. Air burst.

19. If radioactive fallout drops on a cellophane bag containing an apple, we would describe the apple as:

a. Contaminated.
b. Radioactive.
c. Exposed to nuclear radiation.
d. Dangerous to eat.

20. The type of burst that produces the greatest area of serious fallout is the:

a. Surface burst. b. Subsurface burst. c. Air burst.

21. A person exposed to 100 roentgens over a two-week period would:

a. Be expected to die.
b. Be quite ill, but could survive.
c. Be expected to survive, and not have any of the symptoms of radiation sickness.

22. The complete fission of 1 pound of uranium or plutonium releases as much energy as the explosion of _____tons of TNT.

a. 5,000
b. 8,000
c. 20,000
d. 24,000

23. The type of burst that produces the greatest area of ground shock is the:

a. Surface burst. b. Subsurface burst. c. Air burst.

24. The best protection against nuclear radiation is:

a. Heavy clothing.
b. Adequate shielding.
c. Antibiotics.
d. Neutralization by alcohol.

25. The type of burst that produces the greatest area of fire is:

a. Surface burst. b. Subsurface burst. c. Air burst.

FINAL REVIEW

Answer Sheet

Question	True	False		
1	___	___		
2	___	___		
3	___	___		
4	___	___		
5	___	___		
6	___	___		
7	___	___		
8	___	___		
9	___	___		
10	___	___		
11	___	___		
12	___	___		
13	___	___		
14	___	___		
15	___	___		
16	___	___		
	(a)	(b)	(c)	(d)
17	( )	( )	( )	
18	( )	( )	( )	
19	( )	( )	( )	( )
20	( )	( )	( )	
21	( )	( )	( )	
22	( )	( )	( )	( )
23	( )	( )	( )	
24	( )	( )	( )	( )
25	( )	( )	( )	

Check for correct answers on page 120.

Your answer: 12 inches of concrete. We disagree.

Concrete is a common material used to provide protection in shelters and is an excellent material to use, but the total weight per unit area of material used is more important than the type of material. Newspaper is a much lighter material than concrete, but we could place enough newspapers between the sources of radiation and ourselves to provide more protection than twelve inches of concrete. This would not be practical because the wall would have to be much thicker than the twelve inches of concrete. Remember, it is the total weight per unit area of the material between the source of radiation and the receiver that is important.

Return to page 113 and try again.

Your answer: 1 inch of lead. We disagree. Lead is an excellent material for protection because of its weight, but the total weight of material is more important than the type of material. The total weight of 1 inch of lead would not be as heavy as some of the other choices listed.

Return to page 113, read the instructions and try again.

Your answer: 60 inches of wood. We agree. We indicated in the chart that 2.5 inches of lead, 24 inches of concrete, and 90 inches of wood provided about the same protection.

Using the chart on page 113, 1 inch of lead would be equivalent to only 10 inches of concrete, and 24 inches of wood.

Sixty (60) inches of wood would provide about the same shielding as 16 inches of concrete or 1.6 inches of lead.

Proceed to page 114 for final review.

Answers to the questions on pages 114 and 115 are as follows. If you miss an answer, see the pages listed below for review.

1.	T	Page 11	14.	T	Page 3
2.	T	Page 8	15.	T	Page 63
3.	T	Page 63	16.	F	Page 8
4.	T	Page 36	17.	b	Page 92
5.	F	Page 25	18.	c	Page 25
6.	T	Page 11	19.	c	Page 82
7.	F	Page 51	20.	a	Page 31
8.	T	Page 8	21.	c	Page 79
9.	F	Pages 13 & 19	22.	b	Page 13
10.	T	Page 76	23.	b	Page 27
11.	T	Page 11	24.	b	Page 90
12.	T	Page 22	25.	c	Page 25
13.	T	Page 36			

Dist: DCPA Staff College

U. S. GOVERNMENT PRINTING OFFICE : 1978 O - 587-651